Can a New Technology Jump-Start a Slow Market Transformation? The Case of the MagnaDrive Adjustable Speed Drive

Philipp Degens, Northwest Energy Efficiency Alliance, Portland, OR
Ken Seiden, Quantec LLC, Portland, OR

Abstract

The Northwest Energy Efficiency Alliance (Alliance) and the MagnaDrive Corporation have formed a public/private partnership to help commercialize the MagnaDrive adjustable speed drive (MagnaDrive). The MagnaDrive is an innovative speed control device that transmits torque over an air gap through the use of powerful permanent rare-earth magnets. MagnaDrive is currently focussing on the wastewater treatment (WWT) and pulp and paper (P&P) markets. These were viewed as good target markets due to high levels of electric motor energy use and low penetration levels of variable speed drives. Also with less than 40 P&P mills in the Pacific Northwest and 70 WWT plants in the region responsible for the bulk of the electricity used in that sector the company sales and marketing efforts could be clearly directed.

The evaluation clearly highlighted many of the challenges in bringing a new product to market. In both the targeted industries, the users report to be satisfied with the existing VSDs and are fairly conservative where new technologies are concerned. These are two vary large hurdles as well as the industry focus on product reliability that is based on product track record that a new technology to have. The low level of VSD penetration in these industries as well as the interest in reliability in the production process indicate that there is an opportunity for MagnaDrive to make market inroads. With the continued trend in higher energy costs, the ongoing broadening of MagnaDrive's distribution network, and MagnaDrive's focused marketing approach, this ASD is well positioned to help expand the speed control market.

Introduction

The Northwest Energy Efficiency Alliance (Alliance) and the MagnaDrive Corporation have formed a public/private partnership to help commercialize the MagnaDrive adjustable speed drive (MagnaDrive). The MagnaDrive is an innovative speed control device that transmits torque over an air gap through the use of powerful permanent rare-earth magnets. Mechanical adjustment of the size of the air gap allows for speed control[1]. The MagnaDrive is viewed by the Alliance as a product that will help expand the speed control market into niches that have received less attention by the electronic variable speed drive (VSD) manufacturers.

The national market for VSDs is dominated by 11 large manufacturers and has been growing at a considerable annual rate of nearly 25% a year (Easton Consulting, June 2000, 20). However sales of new and market penetration in existing motor systems in the USA remain quite modest with only 18% of new and 12% of existing installations having VSDs installed. In comparison 24% of new and 19% of existing motor systems in Europe have VSDs installed and in Japan 45% sold and 38% installed motor systems have VSDs (Motor Systems Resource Facility, Jan. 2000, 10). This is an indication that there are many motor applications in USA that could benefit from speed control and that there is

---

[1] For more information see Motor Systems Resource Facility 2000 report or magnadrive.com

further room to accelerate the market penetration in the USA. There are also a number of niches markets where VSDs are hypothesized to have lower penetration rates such as medium voltage (MV) drives where VSDs cost about 30% more per horsepower, retrofit applications where the perceived risk of damaging older non-inverter duty motors is high, rough duty applications where cost of housing the VSDs can be prohibitively expensive, and nontraditional variable load applications (e.g. seasonal or annual).

The Alliance and MagnaDrive have been working together since May 1999. The first phase of the project involved:

- Testing and comparing the MagnaDrive to VSDs at Oregon State University's Motor Systems Resource Facility
- Case studies of MagnaDrive installations at five industrial sites
- Marketing and marketing materials development

The findings from Phase 1 concluded that the MagnaDrive is a viable simple, non-electronic, adjustable speed drive (ASD) that provides, up to 30% power reductions on baffled fans and 44% on throttled pumps (Motor Systems Resource Facility 2000, 9). This is, on average, about two-thirds of the energy savings of a comparable VSD in pump and fan applications and can be used in many applications where a VSD would not be cost-effective to install. The MagnaDrive also offers a number of benefits in comparison to an electronic VSD that will support the growth of the speed control market – potentially lower costs for larger MV motors, mechanical operating advantages such as reduced noise and vibration, reduced bearing temperatures, 100% turndown ratio, infinite speed control, the ability to start the motor uncoupled from the load, and electrical benefits such as reduced and shorter in-rush currents, reduction in total harmonic distortion, and higher power factor. However, three key market barriers were identified in Phase 1:

(1) Lack of in-field performance data for larger motors (>500 horsepower),
(2) Lack of knowledge about the MagnaDrive as a product and technology, and
(3) Lack of brand recognition in the marketplace of both the MagnaDrive ASD and the Corporation.

The overall findings from Phase 1 has led the Alliance to fund a Phase II research effort designed to address these barriers. Phase 2 provides funding for additional performance testing of the large horsepower couplings as well as vertical hollow shaft irrigation pumping applications. A number of case studies documenting how the MagnaDrive performed in these two types of applications are currently being designed. Funds are also provided for continued and expanded marketing of the existing tested 25-500 HP drives with an initial focus on the pulp and paper (P&P) and water and wastewater markets in the Pacific Northwest. These target industries were selected due to their high energy consumption and the large pump and fan loads that can benefit from speed control. Earlier studies had also indicated that the penetration of speed control in these industries was fairly low. The P&P industry with approximately 40 plants in the region are the industrial sector with the greatest motor related energy use consuming about 10,000 GWh a year (Easton Consulting, Dec. 2000, 5). The municipal water and wastewater industry has approximately 825 wastewater treatment plants and uses 1,300 GWh per year (Quantum Consulting, May 2001, 1-1). Energy consumption in the wastewater treatment market is highly concentrated with 20 large plants consuming over 40% of the energy.

Evaluation Approach

Evaluation of the project had five major components:

1. Documenting the history of MagnaDrive including activities outside of the scope of the project such as national and international markets as well as other non-ASD products that the firm is commercializing and marketing.
2. Review of product marketing activities
3. Review of ASD acceptance in the targeted industries and impacts on these markets
4. Review of existing savings estimates and Alliance cost effectiveness assumptions
5. Quantification of non-energy benefits in life cycle cost comparisons of the MagnaDrive against other speed control devices.

This paper provides a progress report on the findings of both phases of this project, concentrating on the following:

- The response from early adopters: process-related problems addressed by the MagnaDrive, realized energy savings, non-energy benefits, customer satisfaction, and any unexpected issues
- The ability of the Alliance and MagnaDrive to directly address and overcome market barriers.
- The challenges faced by an emerging company and technology in trying to penetrate the speed control market, competitive responses, and impacts on overall market growth.

The evaluation team is led by **quantec** LLC and includes Schiller Associates, Xenergy, and Market Link Strategies. They have currently completed the first market progress evaluation report.

The evaluation team conducted interviews with a number of customer purchasers and non-purchasers to assess current practices, attitudes, and awareness of the MagnaDrive and the speed drive market. Interviews were conducted primarily with members of the wastewater treatment (WWT) and pulp and paper (P&P) industries (Table 1).

Table1
Number of End Users Interviewed

Group	Number Available	Number of Interviews Completed	Business Sector for Completions		
			P&P	WWT	Other
1. Customers at demonstration sites	5*	4	2	1	1 large commercial building
2. Customers with no Alliance funding	7*	6		4	1 irrigation, 1 electric power plant
3. Non-purchasers familiar with MagnaDrive	12 (5)*	3	0	3	
4. Non-purchasers not familiar with MagnaDrive in targeted industries	875**	9	5	4	

* MagnaDrive provided customer contacts. Of the non-purchasers, 4 were WWT and there was one P&P company.

** The Alliance and the quantec team developed a database of approximately 875 potential customers in the Wastewater (825) and Pulp & Paper segments (50)

Water and Wastewater Treatment

The typical flow of the WWT plants surveyed range from 3 MGD to 120 MGD. The population served by these facilities ranges from about 50,000 to 500,000. Population, however, is not always a good predictor of WWT size. Residential wastewater contributes about 70% to 80% of the plant flow in most cases. However, two of the plants interviewed have commercial and industrial flows that contribute nearly three-quarters of the plant flow.

The motor sizes of the plants surveyed range from fractional to up to 1000 HP. About 80% of the motors were 50 HP or less, about 16% were between 50 HP and 250 HP, and about 3% were above 250 HP. For wastewater treatment plants, however, most of the large motors (200 HP and up) were for the aeration blowers in the activated sludge process, which accounts for 50% or more of the total energy usage for wastewater treatment plants (Quantum Consulting, May 2001, 3-11). Activated sludge is the most common secondary process for treating wastewater. Water and wastewater treatment plants generally use 460/480Volt systems. Only a few very large motors (e.g., 1,000 HP aeration blowers) use 2,300V or 4,160V systems.

Most plants have no standard O&M procedures but spend much time in preventive maintenance (PM) of the motors and motor-driven equipment. Typical PM tasks include vibration testing, motor testing, and balancing. Virtually all respondents indicated vibration testing as part of their PM program. Some of the common motor problems include bearing failures, vibration, and motor overloading.

WWT maintenance and operation supervisors generally select the equipment to be purchased and submit the purchase request to the director of the plant. Since most water and wastewater treatment plants are public facilities, the City Council or the Board would make the final purchase decision.

The respondents indicated that payback and life-cycle cost analyses were performed for purchasing and installation of motors and motor drives. Some respondents indicated that the first costs were also important in decision-making. Energy efficiency is also an important purchasing criterion, but is often outweighed by process-related issues such as load balancing and vibration.

Most of the respondents could not accurately estimate the variability of loads. However, VSDs have significant penetration for the plants surveyed; 11 of the 12 plants interviewed provided information related to VSD penetration. The average VSD penetration of 40% is much higher than the industry average of 10-12% in the Pacific Northwest. This was because many of the plants had had recent upgrades, which indicates that there are substantial speed control opportunities in older plants.

Most users who purchased the coupling did so to improve production processes, and reduce overhead and maintenance (O&M) expenditures and downtime. The WWT plants typically had many motors covering a large range of sizes, and speed control capability was desirable for most. Generally, speed control was important because of the need to handle varying water flows. Other reasons given for purchasing were to reduce intake water spillage, to save energy on the blowers that provide oxygen to the plant's digesters, vibration reductions and mitigation of shaft alignment problems, which should increase the pump life, solving the cavitation problems that were leading to major, and regular failures of their pump supports, bearings, seals, etc. Energy efficiency was considered a nice benefit but often was not the driving factor in making the installation decision. In fact, energy savings were often only important from the perspective of calculating the lifecycle costs or payback period of the equipment, which also includes changes to O&M costs, production efficiencies, etc.

While paybacks or some form of financial analysis is required for purchasing, VSDs were not really being compared to the MagnaDrive in these WWT applications. In one instance, the chief engineer did have to provide a VSD financial comparison, but it was no contest because VSD installation costs would have been far higher and more complex. They would have had to construct an

additional room because of space constraints in current pumping room, plus it would have needed to be protected from water. The simplicity and apparent low maintenance requirements of the MagnaDrive are other inherent characteristics important in applications where there may be a small or inexperienced maintenance staff. Most of the MagnaDrive purchasers also had experience with VSDs and reported various problems with them.

Most of the purchasers' reactions to the technology were very positive. All respondents gave the technical concept of the MagnaDrive high marks and reported that the unit appeared to be professionally designed and manufactured. There were mixed reviews, however, on the performance. Most end users felt that the units delivered on their promises, but there were some surprising performance shortfalls. Noise and heat were mentioned by a few end users. *Increased* energy consumption was a complaint of one user, but evaluators believed that this finding was the result of a flawed measurement approach. The reactions to the installation process were also mixed. Customers were generally positive about the installation experience when the assembly line or process could be shut down for several hours with no problem, but they were unhappy when a relatively long shut down was not feasible or was very expensive.

The most important litmus test, however, was customer interest in installing another drive, and more than half of the respondents (five) said they had already purchased another MagnaDrive, while three others said they were likely to purchase another. However, they are not buying several at a time. Repeat purchases typically involve buying one or two ASDs for specific applications in the next capital budgeting cycle. These applications tend to be specific motors with issues such as shaft alignment, vibration, or a need for process speed control. Broader saturation within these facilities will likely require lower MagnaDrive Coupling prices and creative financial solutions to allow WWT agencies to overcome capital budget constraints and the long lead times associated with project approvals.

A difference between purchasers and other WWT firms is that all non-purchasers expressed satisfaction with current VSD operation in their plants and expect increases in the installations of VSDs. With such a small sample size, we cannot say whether or not the problems with VSDs noted by purchasers are systemic within the industry.

Of the three WWT Group 3 contacts, only one had seen the MagnaDrive demonstration and originally had expressed an intention to install one. The other two learned about MagnaDrive through the website or from maintenance personnel of the plant. The basic reason for non-purchases at these two sites is a lack of information; they would like additional information before they consider MagnaDrive. Information needs mentioned included product and installation costs, efficiency (and comparison to VSD), and product support through vendor or supplier.

MagnaDrive will need to focus more on educating engineering firms about their products, especially the consulting firms to the wastewater industry. One potential customer wanted to purchase the drive to retrofit a six-75 HP motor system, however he did not purchase MagnaDrive because an engineering firm did not recommend it. Apparently, the engineering firm was suspicious about the new product and saw it as a risk. Three of the four WWT contacts surveyed in Group 4 expressed interest in new speed control technologies, including the MagnaDrive. They wanted to see additional information, including product information, efficiency comparison to VSD, reliability, prices, and testimonials.

Pulp & Paper Industry

The P&P plants surveyed contain between approximately 700 and 5,000 motors each. None of the respondents could provide a definitive number of motors at their plant; due to the large numbers of motors, they had to estimate the totals. About half of the motors identified are less than 50 HP,

although several motors in the range of 4,000 HP to 5,000 HP, and one as large as 12,000 HP, are located at the surveyed plants.

VSDs have penetrated all of the pulp and paper mills and were installed in between 6% and 40% of the motors in the plants. In general, the VSDs are installed to provide process control for variable load applications. Most of the VSDs are installed on smaller motors because of the high costs of larger VSDs. Most respondents indicated no major problems with their motor systems or VSDs. There is also agreement among all respondents that the penetration of variable speed control could increase substantially, given reliable equipment and lower prices.

Most plants have semi-formal O&M procedures in place. These firms are very concerned about keeping their motor systems up and running. Downtime is very costly; it can easily exceed $5,000 per hour. O&M is typically done in-house, and costs are generally not tracked or are only partially tracked.

The respondents indicated that several types of cost analyses were performed, and these were not necessarily consistent from facility to facility. For most, a fairly simple analysis, such as simple payback, is performed for smaller motor systems. Surprisingly, most of the respondents indicated that energy efficiency is included in the decision-making criteria. One respondent even mentioned that only energy-efficient equipment is considered for purchase. For larger motor systems, a more complex analysis is usually performed, such as life-cycle costs. Here again, most include energy efficiency in the analysis. While most of the plants have a motor repair/replacement plan, they typically do not consider early replacement of their motors. Similarly, while most of the respondents indicated that mean time between failure is an important value for motors and couplings; respondents did not track this value. The same decision-makers are responsible for purchasing both motors and drives at the plants surveyed. These decision-makers, in general, consisted of plant supervisors and engineers. One respondent, however, mentioned that the CEO made the final purchase decision for large motors.

As there were only two P&P purchasers in our sample, it is difficult to generalize. Both purchases were as part of a case study and thus received some Alliance matching funds. Also one was the first installation of a MagnaDrive. In one application the customer was only interested in speed control and energy savings and the Alliance co-funding made the installation financially attractive. For the second vibration, maintenance costs and alignment problems were the economic drivers to the purchase decision the energy savings benefits were also recognized. In their cost calculations the MagnaDrive had lower costs than a VSD.

The second P&P customer was quite satisfied with the installation process; their only complaint was that it would have helped if they knew in advance what skills would be needed to do the installation. They did know that they needed instrumentation and control, but their electrician was on vacation, and this was a problem. He did say that the learning process was very straightforward and that "the next one should go just fine." They are also very satisfied with performance to date. They recently measured the vibration and it is, as expected, extremely low. The installation process at the first P&P plant was the very first commercial installation of the MagnaDrive coupling and that installation performance as reported by other customers has improved markedly over time. Despite the fact that the customer had not fully prepared for the installation and this was a learning experience for MagnaDrive, the installation was completed well within what was a normal shutdown of the plant.

Five P&P companies who were not familiar with the MagnaDrive were interviewed. However, they were all are very familiar with motors and drives, and most of the people were decision-makers for equipment purchasing. Their two main decision criteria were reliability and cost. Pulp and paper manufacturers want reliable variable speed control and are willing to pay for it – up to a point.

Generally, the people interviewed are satisfied with their existing VSDs. However, the low penetration level – especially for high horsepower equipment – provides ample opportunity for MagnaDrive to enter the marketplace if they can produce a relatively inexpensive product. If

MagnaDrive is successful in bringing to market their product in the large horsepower range where VSDs are expensive, they should be able to penetrate.

Interviews with P&P firms indicated that MagnaDrive will need to work through normal equipment distribution channels to gain a significant foothold in this industry. The P&P industry is more conservative than the WWT industry. Nobody wants to be the first to try out a new technology.

Summary of Interview Findings

- The WWT and P&P industries can be considered conservative in the installation of new technologies. However, both sectors have good perception of VSDs, and are interested in new speed control technologies. This is seems especially true in the WWT industry with the much higher VSD penetration in the newer plants, and the plants that had recent upgrades and renovations. In general, VSD penetration is estimated to be 10-12%. Given the low VSD penetration and the fact that most respondents expect the penetration of speed control devices to increase in the future, there is significant potential for the application of the MagnaDrive in the WWT market.
- MagnaDrive will need to focus more on educating WWT engineering firms about their products.
- It appears that, if the price of VSDs continues to decline, the P&P industry will add variable speed control devices on large numbers of their motors. Lower prices will be needed to make inroads into this industry.
- Give the nature of a new product it is more difficult to address the reliability issue. MagnaDrive needs to document the operations of the ASD in those applications where it has been used the longest. This will become increasingly important as sales move from early adopters to a broader customer market.
- Customers in both sectors appear to be fairly selective when making capital purchase decisions. Initial sales do not appear to lead a customer to decide to install couplings on every pump and fan application. Instead, customers appear to be making purchase decisions on an application-by-application (or motor-by-motor) basis. This suggests that that the purchase decision in many facilities may need to be measured in years. This time-to-market issue should be considered in MagnaDrive's marketing and distribution plan.

  However, the market potential for MagnaDrive will be:

  - Where motors have variable loading and mechanical problems such as vibration
  - Where a VSD would be a good solution to process control but would generate intolerable harmonics in the electrical system or intolerable vibration in the mechanical system
  - Where MagnaDrive has a price advantage over VSDs (large medium voltage motors)
  - In retrofit applications where the customer has older, sound working motors but is nervous about using VSDs that might lead to premature "burn out" and motor replacement.

Market Potential Update

While there are 825 WWT plants and 40 P&P plants in the Pacific Northwest, there are only a small number of very large customers in both of these industries. However, nearly all of these customers have motor applications that can benefit from the MagnaDrive. Of the 825 WWT plants, about 70 have design flows of over five million gallons per day (MGD), and about 20 have design

flows of over 20 MGD. These are responsible for most of the energy consumed by the sector, and the probability of the plant having medium voltage applications will be greater as the size of the plant grows.

MagnaDrive's annual Northwest WWT and P&P sales could be quite substantial given the current level of market penetration of VSDs. The most likely candidates in the WWT industry for medium and high voltage applications are plants with activated sludge facilities and with flow rates above 5 million gallons per day while all of the P&P plants would prove good potential customers.

It is difficult to quantify the market potential for MagnaDrive in both the WWT and P&P industries. The evaluation estimated ranges were heavily dependent on the following:

- The continuing trend of higher energy prices
- MagnaDrive's ability to broaden its marketing channels to include an array of industry specific market actors: OEMs, distributors, manufacturer representatives, and engineering firms
- MagnaDrive's ability to attain scale economies and compete on both first cost and life-cycle cost bases

Given the low level of current market penetration of VSDs and the potential for both industries to rapidly increase their level of speed control the evaluation estimated energy savings potential of MagnaDrive ranging from about 70 to nearly 700 GWh annually. Note that this is a *cumulative* savings estimate reflecting several years of ASD installations. The low ASD penetrations in these industries represent a significant opportunity for MagnaDrive and its ASD competitors. There are large numbers of motors at each facility, and the people we interviewed indicated that there was high potential for more variable speed control. While non-energy benefits will assist MagnaDrive in the WWT industry, the company will have to compete on a price basis to gain a footing in the P&P industry. If prices do not change significantly, there will not be much additional market penetration of variable speed control devices (both MagnaDrive and electronic VSDs) in the P&P industry.

Marketing Review

The review of the MagnaDrive's marketing approach and materials is a very qualitative assessment. The evaluation team reviewed marketing materials and attended a major WWT trade show with MagnaDrive. The team concluded that MagnaDrive exceeded the minimum corporate communication and market promotion threshold, and designed and developed world-class components of a total communication package. Corporate logos, letterhead and stationery, the display booth, the truck demonstration, show 'uniforms,' technical product descriptions, etc., all reached or exceeded market requirements. Also interviews with MagnaDrive staff indicate that the executive team at MagnaDrive is very aware of and capable of understanding and implementing corporate communication requirements.

The MagnaDrive demonstrations, which included both truck- and table-mounted units, were well attended and credibly presented at the trade show. The corporate logos, letterhead, equipment spec sheets, representative 'booth uniforms,' personnel selling style, and brochures were also well received.

The review resulted in the following findings:

- For MagnaDrive's stage of development, additional investment in market promotion should be focused on lead generation, trade show participation, and providing selling tools to direct and channel marking partners.

- In certain sectors, third party endorsements (e.g., engineering firms, case studies, trade journal articles) are a key aspect of educating prospects.
- MagnaDrive's greatest marketing challenge, as identified in the company's business plan, is developing national distribution.
- Time to market is a significant issue facing MagnaDrive. The Coupling is a capital item and most public and private sector prospects have lengthy (e.g., annual) capital budget cycles, and the public sector prospects (i.e., WWT) face significant budgetary constraints. With only 32 units installed as of the end of 2000 this is a serious hurdle for a small company with limited resources.

Conclusions

With limited sales it is yet too early to determine how MagnaDrive will meet the competitive market pressures. Ongoing market challenges are the continued trend in lower prices in the VSD market, increasing commoditization of VSDs and the fact that existing VSD manufacturers are large well established international firms with wide range of resources that continue to expand into many of the niche markets identified by MagnaDrive.

The evaluation clearly highlighted many of the challenges in bringing a new product to market. In both the targeted industries, the users report to be satisfied with the existing VSDs and are fairly conservative where new technologies are concerned. These are two vary large hurdles as well as the industry focus on product reliability that is based on product track record that a new technology to have. The low level of VSD penetration in these industries as well as the interest in reliability in the production process indicate that there is an opportunity for MagnaDrive to make market inroads. With the continued trend in higher energy costs, the ongoing broadening of MagnaDrive's distribution network, and MagnaDrive's focused marketing approach, this ASD is well positioned to help expand the speed control market.

References

1. Ducker Worldwide, Nov. 2000, Energy Efficiency Within the Pulp and Paper, Water and Wastewater and Irrigation Markets in the Pacific Northwest: An Examination of Pumps, Fans/Blowers and Conveyor equipment, NEEA 00-067, Portland, Oregon: Northwest Energy Efficiency Alliance.
2. Easton Consulting, Inc. June 2000, Market Research Report: Variable Frequency Drives, NEEA 00-054, Portland, Oregon: Northwest Energy Efficiency Alliance.
3. Easton Consulting Inc. and Xenergy, Inc., December 1999, Assessment of Industrial Motor Systems Market Opportunities in the Pacific Northwest, NEEA 00-054, Portland, Oregon: Northwest Energy Efficiency Alliance.
4. Motor Systems Resource Facility, Oregon State University, January 2000, Laboratory Testing of the MagnaDrive Adjustable-Speed Coupling System (ACSC), NEEA 00-048, Portland, Oregon: Northwest Energy Efficiency Alliance.
5. Quantum Consulting Inc. and Adolfson Associates Inc., Pacific Northwest Water and Wastewater Market Assessment, May 2001 (forthcoming), Portland, Oregon: Northwest Energy Efficiency Alliance